A2 PHYSCIS 9702

Crash Course

TEMPERATURE

COMPLETE NOTES

Temperature :- Measurement of the average Kinetic energy of particles of a substance.

Centrigrade scale :- Based on the melting and boiling point of water at r.t.p

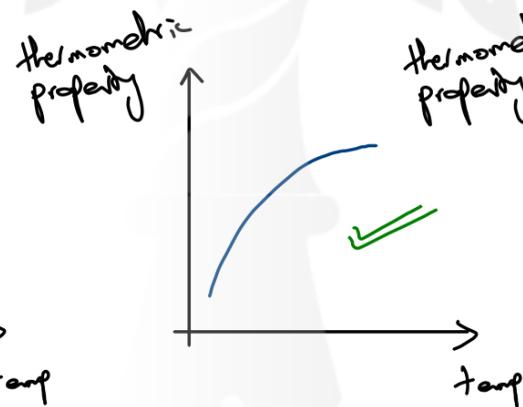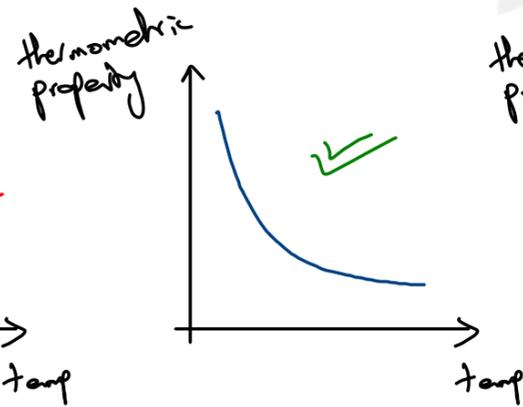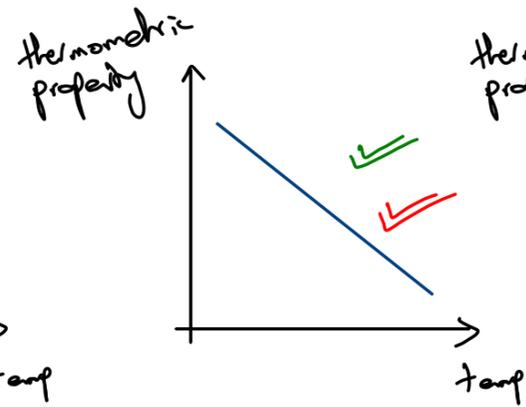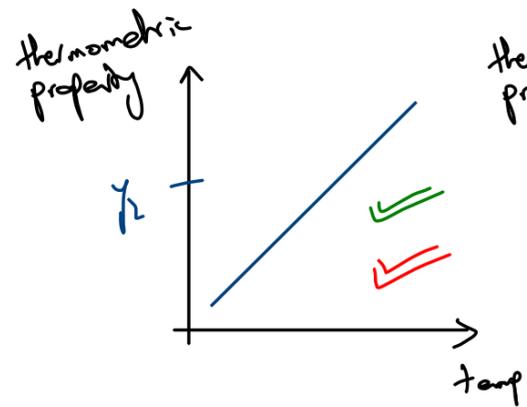   fixed points :- $0°C$ & $100°C$ (Divided into 100 parts)

   ↪ Later became Known as Celsius scale (Eradicated because of its dependency on water and atmospheric pressure)

Thermometric property :- Property of a material that allows you to measure temperature as it varies <u>monotonically</u> with temperature.

linear relationships are best $\left(y = mx + c \right)$

Thermometric property :-
1) Volume → Mercury/Alcohol
2) Resistance → thermistor
3) Pressure → Constant volume gas
4) E.m.f → thermocouple
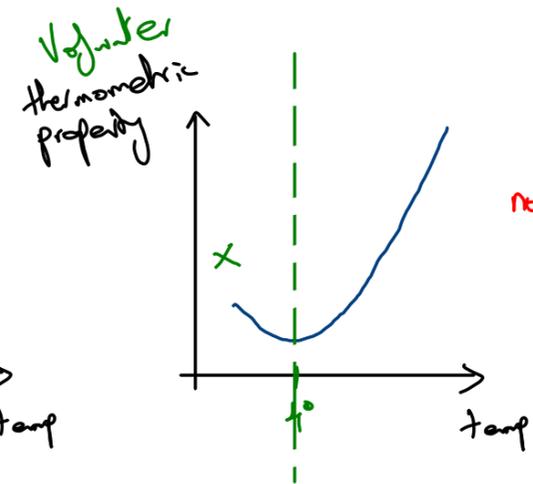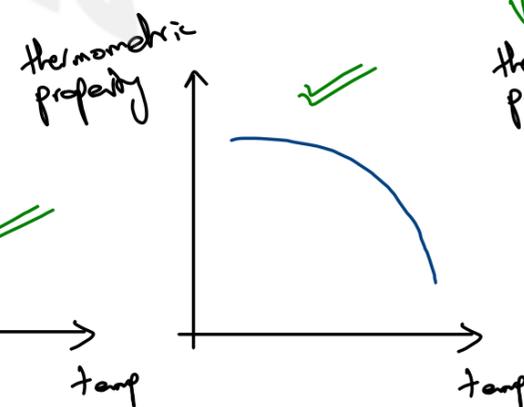
not monotonous

Anomalous expansion :-
$0° → 4°$ ⇒ contract
$0° ← 4°$ ⇒ expand

We wanted to move away from these dependencies of thermometric properties and inconsistency of the celsius scale.

Hence, Absolute scale (Measured in K)

$$\boxed{K = {}^\circ C + \underline{273.15}}$$

$\hookrightarrow$ strictly use this

fixed points :- 1) 0.0 K, Absolute zero $(-273.15\,^\circ C)$
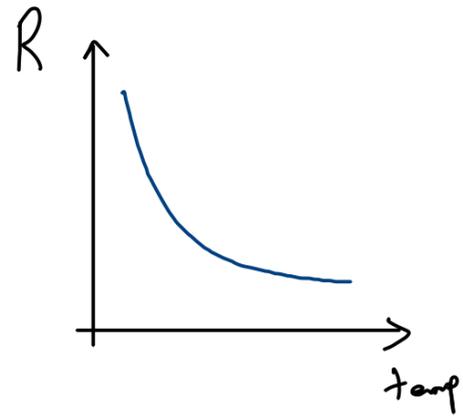
2) 273.16 K, triple point of water (at 0.006 atm, water, vapour, and ice all 3 states can coexist at 273.16 K or 0.01°C)

Divided into 273.16 divisions

Thermistor :- Resistance based thermometer

R

temp

Normally :- When temp $\uparrow$ $\Rightarrow$ K.E of particles $\uparrow$ $\longrightarrow$ lattice vibrations $\uparrow$ $\longrightarrow$ hindrance $\uparrow$ $\longrightarrow$ $R \uparrow$

Q. Why do thermistors behave differently?

Ans. They are made up of semiconductors

$T \uparrow$ $\longrightarrow$ you give energy to electrons $\longrightarrow$ They jump to higher conduction bands $\longrightarrow$ delocalization of electrons occurs $\longrightarrow$ Current increases $\Rightarrow$ $R \downarrow$

Thermocouples:- E.m.f based thermometer. It works on Seebeck effect.
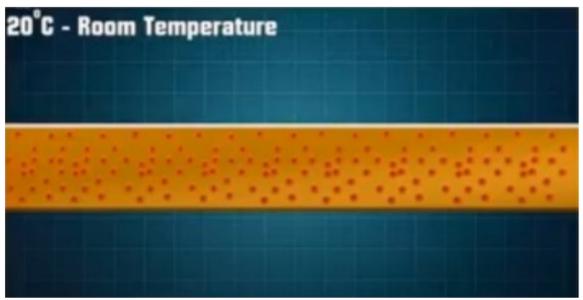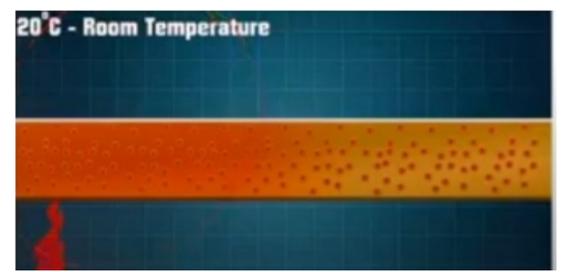

Free moving electrons in conductors

Heating one end, will give energy to the electrons and they will start moving to colder side.
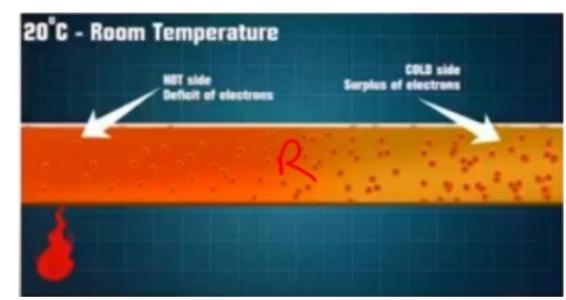
Hence a current forms ⟹ $V = IR$
↓
Voltage produced
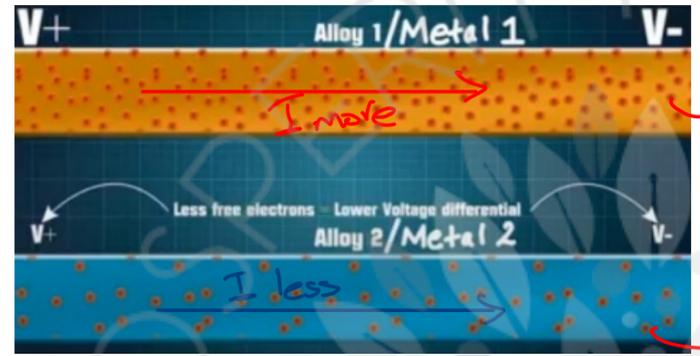
→ more no density of electrons

→ less no density of electrons

Using 2 different materials with different no. densities, different voltages develop on them for the same temperature difference

→ copper

→ zinc
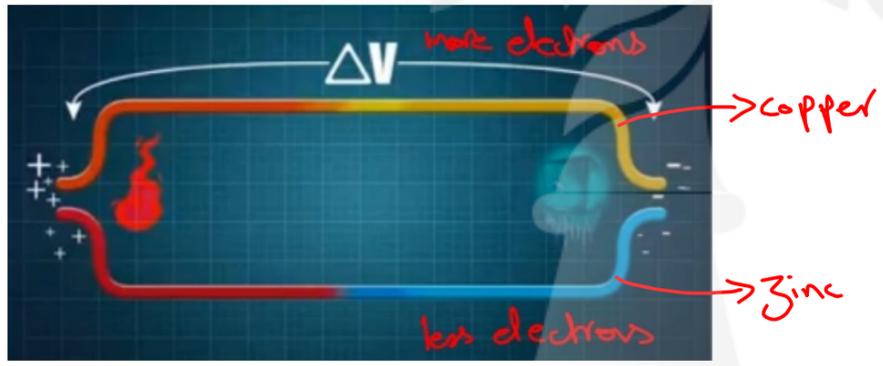
Over the whole system, a change in voltage is produced.

Opposite of Seebeck effect:-

Peltier effect

(Voltage ⟹ temp diff)

Thermocouple :-

$$E.m.f \propto \Delta temp$$

COMPARISON BETWEEN THERMISTORS AND THERMOCOUPLES

|	THERMISTOR	THERMOCOUPLE
ADVANTAGES	1) They are accurate 2) They have a high range 3) Mostly used where temperatures remain constant (very small fluctuation/change) 4) Ideally suited between -55 and 120 C 5) Robust	1) Sensitive 2) Wide range 3) Ideally suited for rapid changes in temperature 4) Suited for localized measurements, isolated places (can be used as probes) 5) Ideally suited between -200 and 1500 C 6) Robust
DISADVANTAGES	Not good for rapidly changing temperatures, low responsiveness	Not very accurate

Accurate:- How correct is the measured temperature value

Sensitive:- How small of a change can a thermometer register

Responsiveness:- How quickly you can measure temperature changes

Range:- Maximum and minimum values of temperature you can measure
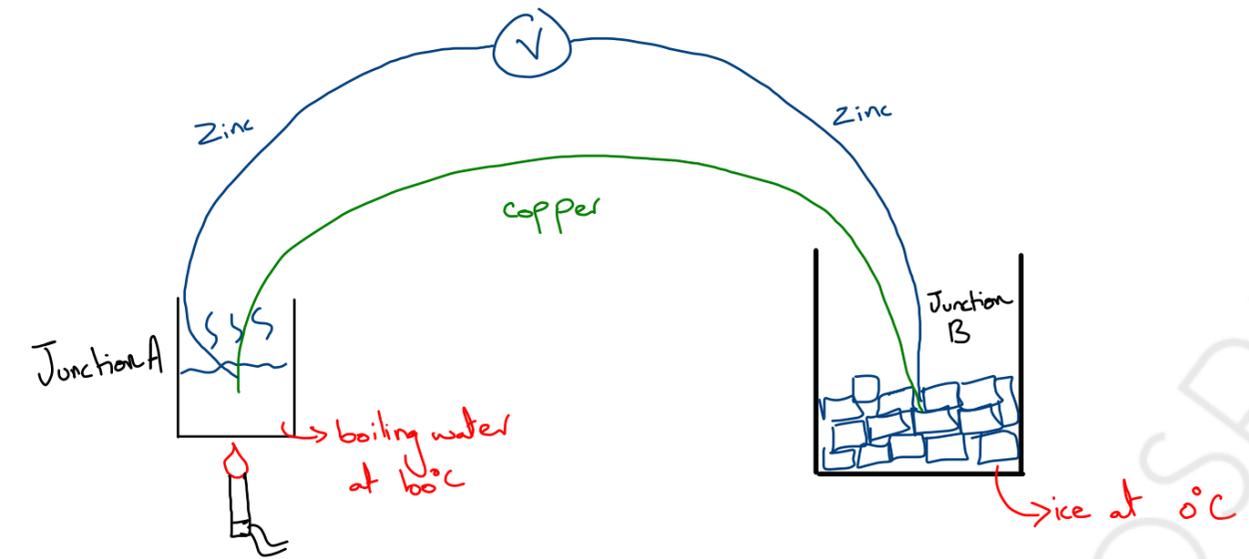
A thermocouple is made by keeping it's junction B fixed in ice at 0°C. The junction A is first inserted into boiling water (100°C), and the voltmeter gives a reading of +4.5V. Junction A is now removed and inserted into a fluid of unknown temperature. The voltmeter gives a reading of -2.25V. Find the temperature of the fluid.

E.m.f $\propto$ Δtemp

$$\frac{E.m.f_1}{\Delta temp_1} = K = \frac{E.m.f_2}{\Delta temp_2}$$

$$\frac{+4.5}{100-0} = \frac{-2.25}{T-0}$$

$$T = \frac{-2.25 \times 100}{4.5} = -50°C$$

7 The e.m.f. generated in a thermocouple thermometer may be used for the measurement of temperature.

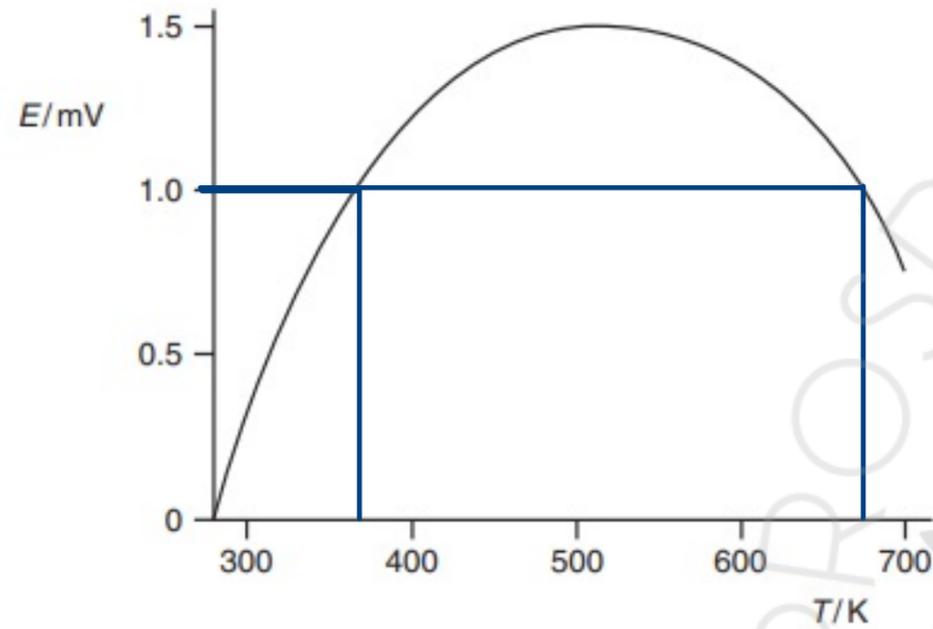Fig. 7.1 shows the variation with temperature T of the e.m.f. E.

Fig. 7.1

(a) By reference to Fig. 7.1, state two disadvantages of using this thermocouple when the e.m.f. is about 1.0 mV.

1. ~~Two values of temp for e.m.f = 1.0 mV~~

2. ~~Non linear graph~~ ....[2]

(b) An alternative to the thermocouple thermometer is the resistance thermometer.

State two advantages that a thermocouple thermometer has over a resistance thermometer.

1. ~~High responsiveness / High range~~

...

2. ~~High sensitivity~~

....[2]

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3 **(a)** The resistance of a thermistor at 0 °C is 3840 Ω. At 100 °C the resistance is 190 Ω. When the thermistor is placed in water at a particular constant temperature, its resistance is 2300 Ω.

(i) Assuming that the resistance of the thermistor varies linearly with temperature, calculate the temperature of the water.

$$y - y_1 = \frac{y_2 - y_1}{x_2 - x_1}(x - x_1)$$

$$2300 - 3840 = \frac{170 - 3840}{100 - 0}(T - 0)$$

$$T = 42.19 °C$$

$\sim 315.15 K$
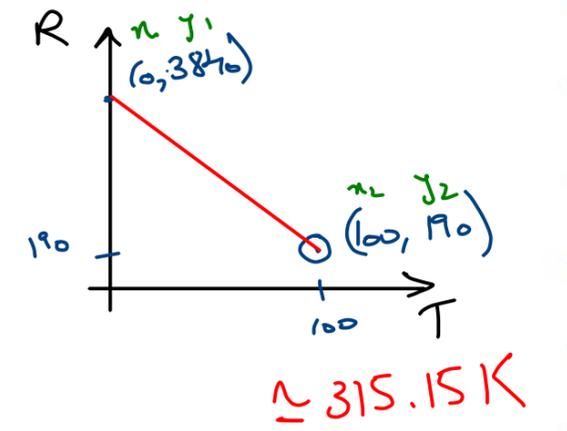
temperature = ...42...... °C **[2]**

(ii) The temperature of the water, as measured on the thermodynamic scale of temperature, is 286 K. ← absolute scale

By reference to what is meant by the thermodynamic scale of temperature, comment on your answer in **(i)**.

~~The thermodynamic scale is the absolute scale. It uses 2 points; the triple point of water and absolute zero to make a linear relationship. Since the reading of the thermistor is 315.15 K, it tells us that the resistance must be varying non linearly.~~ **[3]**